

### Patent Claims

1. A laser-based device for non-mechanical, three-dimensional trepanation during cornea transplants, comprising
  - a computer-assisted control and regulation unit (4) provided with at least one control computer (5, 6, 7) and at least one display unit (8, 9), as well as
  - a laser source (2) for generating a working laser beam (3),  
**characterized by**
    - a multi-sensor processing head (1) integrated into which are:
      - 10 = an axial beam guiding system (11) into which the working laser beam (3) is coupled,
      - = a focal point tracking unit (12) for the z-position displacement of the focal point (13) of the working laser beam (3)
      - = an x-y-scanner unit (14, 15) for the x- and y-position displacement of the working laser beam (3),
      - 15 = an eye position sensor unit (23, 24, 35, 36) for detection of the position of the eye, and
      - = a plasma sensor unit (16, 25) for detection of the plasma glow that occurs during the cornea trepanation.
- 20 2. A trepanation device according to claim 1, **characterized by** an adjusting laser (17) whose visible adjustment beam is coupled into the axial beam guiding system (11) via a deflection prism (18) that is positionable in x-y-z direction.
- 25 3. A trepanation device according to claim 1 or 2, **characterized by** an infrared illuminating unit (19) whose infrared beam (20) is coupled into the

axial beam guiding system (11) via a deflection prism (21) that is positionable in x-y-z direction.

4. A trepanation device according to any of the above claims, **characterized in that** the focal point tracking unit (12) comprises adaptive optics or  
5 a displaceable telecentric focussing lens (37).
5. A trepanation device according to any of the above claims, **characterized in that** the x-y scanner unit comprises a rough adjustment unit (14) with two adjusting axes (26, 27) and a fine adjusting unit (15) preferably with piezo-driven tilting mirrors (33, 34).
- 10 6. A trepanation device according to claims 4 and 5, **characterized in that** the x-y scanner unit (14, 15) and the focal point tracking unit (12) comprise position feedback outputs, which are coupled with the control and regulation unit (4) for controlling the actual x-y-z position of the focal point (13) of the working laser beam (3).
- 15 7. A trepanation device according to any of the above claims, **characterized in that** the eye position sensor unit comprises two CCD line scan cameras (23, 24) that are orthogonal in their line orientation.
8. A trepanation device according to any of the above claims, **characterized in that** the eye position sensor unit comprises two laser distance sensors (35, 36), one of which determines its distance to the center of the cornea being treated and the other determines its distance to a rim point of the  
20 cornea.
9. A trepanation device according to any of the above claims, **characterized in that** the plasma sensor unit is formed by a CCD area scan camera

(25) for position-resolved detection of the plasma glow, or by a plasma sensor (16).

10. A trepanation device according to claim 9, **characterized in that** the image data of the CCD area scan camera (25) is used for determining the pupil contour of the eye being treated.

11. A trepanation device according to any of the above claims, **characterized by** a laser output sensor (22) in the multi-sensor processing head (1).

12. A trepanation device according to any of the above claims, **characterized in that** a surgery microscope (32) is integrated into the multi-sensor processing head (1).

13. A trepanation device according to any of the above claims, **characterized in that** the control and regulation unit (4) comprises a central control computer (5), a positioning computer (6) that is coupled with the CCD line scan cameras (23, 24) and with the infrared illuminating unit (19), and a control computer (7) that is coupled with the CCD area scan camera (25).

14. A trepanation device according to any of the above claims, **characterized in that** the display unit comprises multiple displays (8, 9) for displaying a real-time image of the eye being treated with the plasma glow and displaying planning, monitoring and simulation images and data.